Helicopter Drag Fuselage- Combined CFD and Experimental Studies

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Abstract

Helicopter drag is relatively high in comparison to aeroplanes and this is partly due to the contributions of the fuselage. In general, helicopters are not streamlined enough and their fuselages have large areas of flow stagnation as well as rear-facing surfaces with suction. In addition, the presences of added components to the fuselage like external fuel tanks, mission equipment, skids etc contributes further to the drag. Consequently, several studies [1,2] have been directed towards estimating fuselage drag and devising design changes that could lead to drag reduction. Examples of these studies have been reported in the literature [3] using several flow models, including even Navier-Stokes simulations based on the URANS or DES approach.

In this work, experiments are combined with CFD aiming to analyse the aerodynamics of realistic fuselage configurations. For this purpose two development models used for the ANSAT aircraft are used as well as an early model of the AKTAI light helicopter. Figure 1 shows the models of the two categories of helicopters. Both feature characteristics of real designs with engine fairings, bubble windows, engine covers and rear-facing surfaces. The models were selected to include as many features as possible and are constructed in a modular way to allow for hubs, external fuel tanks skids etc to be added. Al models were tested at the subsonic wind tunnel of KNRTU-KAI for a range of Reynolds numbers, pitch and yaw configurations. Figure 2 shows typical force measurements along with the experimental error in the estimates of steady force coefficients. On the same figure, estimates obtained with computational fluid dynamics are also presented. Interestingly, the drag coefficient of the more streamlined ANSAT-like fuselage shows larger discrepancies with CFD than the AKTAI-like model that is dominated by flow separation at its rear. The force balance measurements were complemented by PIV investigations for the cases where the experimental force measurements showed substantial unsteadiness. From the complete database of force measurements and the PIV explorations, indicative results are shown in Figure 3 where the PIV and CFD results for the rear fuselage of the AKTAI are compared. The two images have the same colour scale, representing velocity magnitude and show substantial similarity. Figure 4 presents the surface pressure coefficient obtained by CFD for the two models computed at the same Re number of 3.2 million and for a range of pitch and yaw angles. The results show the areas of stagnation at the front of the bodies that contribute, in part, to the overall drag of the fuselages. A substantial database of experiments has so far been compiled and is exploited for the validation of CFD.

The details of the experimental setup, instrumentation and detailed results, along with the CFD analyses performed for this case are presented in the complete version of the paper.

Acknowledgements

This work is supported by the "Leading Scientist" grant of the Russian Federation, under order 220 of the Russian Ministry of Education. The authors would like to acknowledge the support of the Kazan Helicopter Plant in providing the initial fuselage shapes for this research. In particular the contributions of V. Kartashov and A. Garipov are gratefully acknowledged.

References

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Figure 1: Wind tunnel models of the ANSAT-like and the AKTAI-like helicopter fuselages.

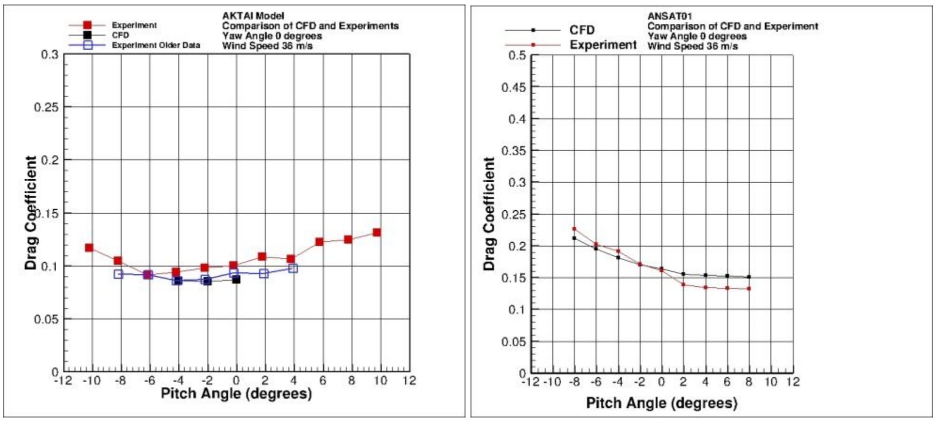


Figure 2: Comparison between CFD and experiments for the drag coefficient of the helicopter fuselages at Re of 3.2 million.

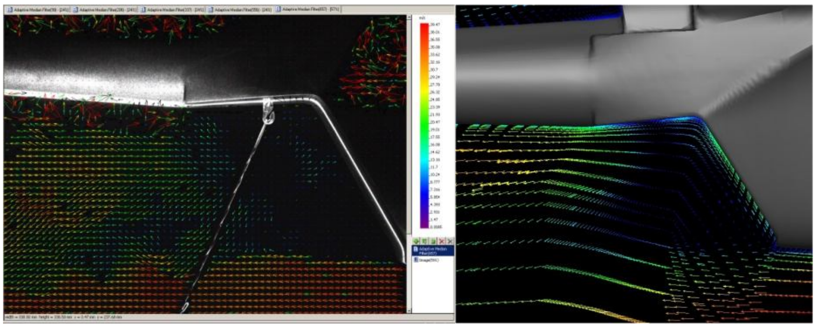
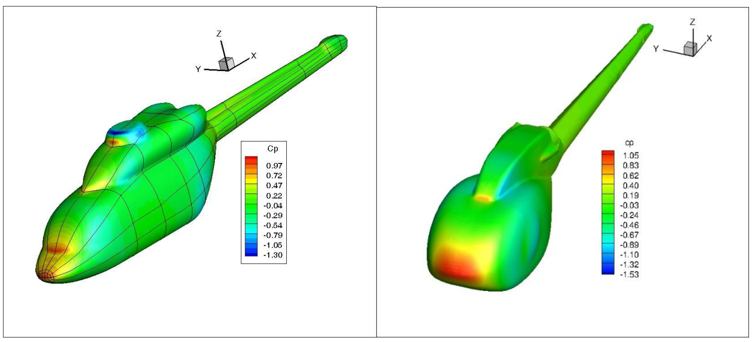


Figure 3: PIV and CFD images showing flow separation behind the AKTAI-like fuselage.



a) b)

Figure 4: Pressure coefficient distributions on the surface of (a) ANSAT-like fuselage for a=0, β=0 degrees, and (b) AKTAI-like fuselage at a=0, β=-2 degrees. The red colour highlights stagnation regions.